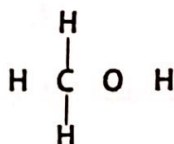


1. (a) The diagram shows the displayed formula of the organic compound methanol, CH_3OH



- (i) Determine the number of atoms in one molecule of methanol.

(1)

~~5~~ 6

- (ii) State why methanol is not a hydrocarbon.

(1)

methanol
Because ~~it~~ contains oxygen

- (b) The atoms in methanol are held together by covalent bonds.

- (i) State what is meant by the term **covalent bond**.

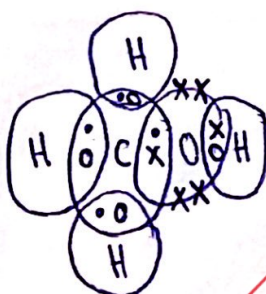
(2)

pair of electrons shared between
two atoms

- (ii) Draw a dot-and-cross diagram to show the bonding in a molecule of methanol.

Show only the outer electrons of each atom.

(2)



(b) Another organic compound has the percentage composition by mass C =

38.7% H = 9.7% O = 51.6%

(i) Calculate the empirical formula of this compound.

(3)

$$\begin{array}{r} \text{C : H : O} \\ 38.7 : 9.7 : 51.6 \\ \hline 12 \quad 1 \quad 16 \\ 3.225 : 9.7 : 3.225 \\ \hline 3.225 \quad 3.225 \quad 3.225 \\ 1 : 3 : 1 \end{array}$$

empirical formula = CH₃O

(ii) The relative molecular mass (M_r) of the compound is 62

Determine the molecular formula of the compound.

(2)

$$\begin{aligned} M_r \text{ of } \text{CH}_3\text{O} &= 12 + (1 \times 3) + 16 \\ &= 12 + 3 + 16 = 31 \end{aligned}$$

$$\frac{62}{31} = 2 \quad \rightarrow \text{molecular formula} = \text{CH}_3\text{O} \times 2 = \text{C}_2\text{H}_6\text{O}_2$$

molecular formula = C₂H₆O₂

molecular formula = C₂H₆O₂
(Total for Question 1 = 11 marks)



2. This question is about elements in Group 7 of the Periodic Table and their compounds. -1

(a) (i) Give the name of this group of elements.

Halide

X Halogens

(1)

(ii) State the colour of chlorine gas.

Pale green

(1)

(iii) Give a test for chlorine gas.

(2)

test with damp litmus paper, it bleaches

(b) Give a test to show that a solution contains iodide ions.

(3)

test

Add nitric acid, add silver nitrate

result

yellow precipitate

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(c) A student compares the reactivity of the elements bromine, chlorine and iodine.

He mixes these pairs of solutions and observes the reactions that occur.

- chlorine solution and potassium bromide solution
- bromine solution and potassium iodide solution

Explain how the reactions can be used to show the order of reactivity of the three elements.

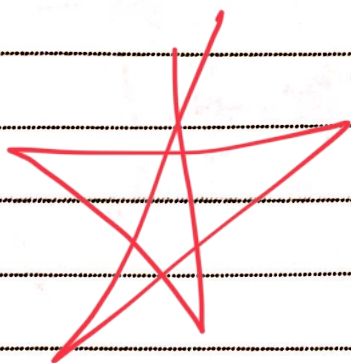
Include the colour change that the student would observe in each reaction.

(6)

Chlorine is more ~~reactive~~ than bromine, so chlorine displaces ~~bromide~~^{ions}, colour of solution turns into orange.

Bromine is more ~~reactive~~ than iodine, so bromine displaces iodine, colour of solution turns into brown.

Reactivity of these elements: chlorine (most reactive), bromine, iodine (least reactive).

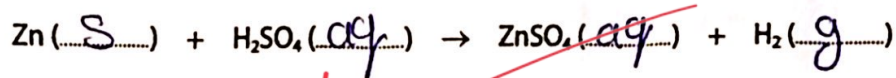


(Total for Question 2 = 13 marks)

3. A student uses the reaction between zinc and dilute sulfuric acid to prepare some zinc sulfate crystals.

(a) (i) Complete the equation for this reaction by giving the correct state symbols.

(1)



(ii) State what would be observed during this reaction.

(1)

Bubbles from hydrogen gas

(b) The student adds excess zinc to a beaker of dilute sulfuric acid.

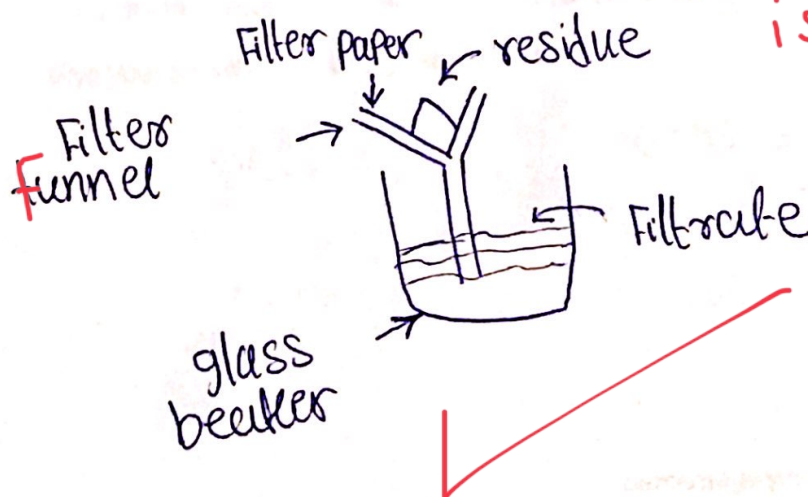
(i) Explain why it is necessary to add excess zinc.

(2)

to ensure that all sulfuric acid has been reacted so more zinc sulfate crystals can be obtained. X

M2 (so that) pure zinc sulfate solution / crystals is obtained

(ii) Draw a diagram of the apparatus the student should use to remove the unreacted zinc and collect the zinc sulfate solution.



(c) The student obtains a pure, dry sample of zinc sulfate crystals.

The formula of zinc sulfate crystals is $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$

(i) Calculate the relative molecular mass (M_r) of zinc sulfate crystals.

$$M_r = 65 + 32 + (4 \times 16) + (2 \times 1) + 16$$

-2

$$= 179 \quad 287$$

$$M_r = 179$$

(ii) The student uses 0.0200 mol of dilute sulfuric acid in her preparation.

Show that the maximum mass of zinc sulfate crystals that the student could obtain is about 6 g.



$$= 287 \times 0.02$$

$$M2 = 5.74 \text{ g}$$

$$0.0400 = \frac{m}{179}$$

$$m(\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}) = 179 \times 0.0400 = 7.16 \text{ g}$$

$$0.0200 : x$$

$$x = n(\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}) = 0.0200 \times 2 = 0.0400 \text{ mol}$$

(iii) The student obtains a mass of 4.28 g of zinc sulfate crystals.

Calculate the percentage yield of the zinc sulfate crystals.

Give your answer to three significant figures.

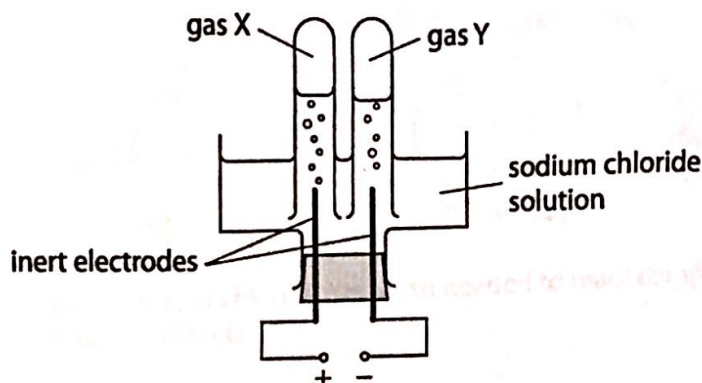
$$\therefore \text{yield} = \frac{4.28}{7.16} \times 100 = 59.777\% = 59.8\%$$

$$\frac{4.28}{5.74} = 0.7456$$

$$0.7456 \times 100 = 74.6\% \quad \text{percentage yield} = 59.8\%$$



- (d) The diagram shows the apparatus a teacher uses to demonstrate the electrolysis of a concentrated aqueous solution of sodium chloride.



During the electrolysis two gases, X and Y, are formed. One of the gases produces a squeaky pop when tested with a lighted splint.

Use ionic half-equations to identify X and Y.

$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$, hydrogen gas will form at the cathode as hydrogen is less reactive than sodium in chemical reactivity series. Hydrogen ions will be attracted to the cathode as they have positive charge, they will gain electrons at the cathode. Gas Y is hydrogen.

$\text{Na}^+ \quad \text{Cl}^- \rightarrow \text{anode +ve}$
 $\text{H}^+ \quad \text{OH}^-$ (4)
 -ve cathode ←

$2\text{Cl}^- - 2\text{e}^- \rightarrow \text{Cl}_2$, chlorine gas will form at the anode as the solution is concentrated, so less OH^- ions, so chloride ions will be attracted to the anode as it has negative charge, chloride ions will lose electrons at the anode. Gas X is chlorine gas.

(Total for Question 3 = 17 marks)



4. Titanium is an important metal in industry.

Titanium dioxide (TiO_2) can be converted into titanium metal in two stages.

Stage 1 titanium dioxide is converted into titanium(IV) chloride (TiCl_4)

Stage 2 titanium(IV) chloride is converted into titanium

(a) This is the equation for the reaction in stage 1.



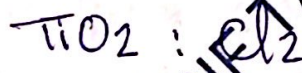
Calculate the volume, in dm^3 , of chlorine gas at rtp needed to react completely with 20 tonnes of titanium dioxide.

Give your answer in standard form.

[1 tonne = 10^6 g M_r of TiO_2 = 80]

[molar volume of chlorine gas at rtp = 24 dm^3]

$$n(\text{TiO}_2) = \frac{20 \times 10^6}{80} = 250000 \text{ mol}$$



$$250000 : x$$

$$x = n(\text{Cl}_2) = 250000 \times 2$$

$$x = 500000 \text{ mol}$$

$$500000 = \frac{V}{24}$$

$$\text{volume of chlorine gas} = 12000000 \text{ dm}^3$$

$$V = 500000 \times 24 = 12000000 \text{ dm}^3$$

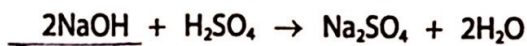
$$M4 \quad 1.2 \times 10^7$$

(b) The student makes the improvements and repeats the titration.

The sulfuric acid has a concentration of 0.600 mol/dm³.

The sodium hydroxide solution has a concentration of 1.50 mol/dm³.

This is the equation for the reaction.



Calculate the volume, in cm³, of sulfuric acid that the student needs to completely react with 25.0 cm³ of the sodium hydroxide solution.

$$n(\text{NaOH}) = \frac{1.50 \times 25}{1000} = 0.0375 \text{ mol}$$



$$0.0375 : x = n(\text{H}_2\text{SO}_4) = \frac{0.0375}{2}$$

$$0.01875 = 0.600 \times \frac{V}{1000} \quad x = 0.01875 \text{ mol}$$

$$V = \frac{0.01875 \times 1000}{0.600} \quad \text{Volume of sulfuric acid} = 31.250 \text{ cm}^3$$

$$V = 0.03125 \text{ dm}^3$$

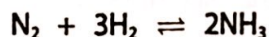
$$V = 31.25 \text{ dm}^3$$

$$V = 31.25 \times 1000 = 31250 \text{ cm}^3$$

$$V \text{ H}_2\text{SO}_4 = \frac{(0.01875 \times 1000)}{(0.600)} = 31.25 \text{ cm}^3$$



- (c) At the start of the reaction, 48 dm³ of nitrogen is added to 120 dm³ of hydrogen at rtp.



[molar volume of any gas at rtp = 24 dm³]

- (i) Show by calculation that the nitrogen is in excess.

$$n(\text{H}_2) = \frac{120}{24} = 5$$

$$n(\text{N}_2)_{\text{used}} = \frac{48}{24} = 2$$

$$\begin{array}{l} \text{N}_2 : \text{H}_2 \\ 1 : 3 \\ x : 5 \end{array}$$

$$n \text{ of } \text{N}_2 \text{ needed} = x = \frac{5}{3} = 1.67 \text{ mol}$$

2 mol of N₂ is used but only 1.67 mol of N₂ is needed.

M3 2.5 mol of hydrogen to 1 mol of nitrogen
(which is less than 3 so nitrogen is in excess)
OR 2 mol of nitrogen needs 6 moles of hydrogen
(so not enough hydrogen to react with nitrogen)

(Total for Question 4 = 10 marks)

5. Lithium, sodium and potassium are the first three elements in Group 1 of the Periodic Table.

(a) Suggest why these three elements are all stored in paraffin oil.

(1)

to prevent these elements from reacting with oxygen

(b) Caesium, Cs, is below potassium in Group 1.

(i) Give a similarity and a difference between the reactions of potassium with water and caesium with water.

(2)

similarity

Both Fizz and moves around

difference

Caesium is more violent and do more vigorous reactions

(ii) Give the chemical equation for the reaction between caesium and water.

(2)



6. This question is about salts.

- (a) Soluble salts can be prepared by the reaction between a metal oxide and an acid.

The equation for this type of reaction is



- (i) State the name given to this type of reaction.

(1)

Neutralisation reaction

- (ii) State, in terms of protons, what happens in this reaction.

Base (metal oxide) is a proton ⁽¹⁾ acceptor ~~donor~~
and acid is proton ~~acceptor~~ donor
so base accepts proton from acid.

- (b) (i) A student is given 50 cm³ of dilute sulfuric acid and a bottle of solid copper(II) carbonate.

Describe the method that the student should use to prepare a saturated solution of copper(II) sulfate.

In your answer, refer to the pieces of apparatus that the student should use.

(5)

-3

use burette to measure acid, add acid into a beaker and add excess of copper(II) carbonate into the beaker (until no more solid can dissolve), stir the solution, wait until copper(II) sulfate crystals form. → leave it to cool and

Filter to get off crystals from solution, wash the crystals

Heat and evaporate all the water using until no more mass change, wash and dry crystals between 2 filter papers



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- (ii) The student produces dry crystals of hydrated copper(II) sulfate from the saturated solution.

He calculates that 6.40 g of dry crystals should be formed.

The mass of dry crystals he actually obtains is 1.80 g less than he calculated.

Calculate the student's percentage yield.

Give your answer to one decimal place.

$$\text{mass he obtained} = 6.40 - 1.80 = 4.60^{\text{(3)}} \text{ g}$$

$$\therefore \text{yield} = \frac{4.60}{6.40} \times 100 = \cancel{71.875\%} = 71.9\%$$

$$\text{percentage yield} = 71.9\%$$

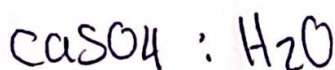
(c) (i) Gypsum is hydrated calcium sulfate.

A sample of gypsum contains 79% of calcium sulfate by mass.

Calculate the value of x in $\text{CaSO}_4 \cdot x\text{H}_2\text{O}$

[M_r of $\text{CaSO}_4 = 136$ M_r of $\text{H}_2\text{O} = 18$]

$$\text{mass of H}_2\text{O} = 100 - 79 = 21\%$$



$$\frac{79}{136} : \frac{21}{18}$$

$$\frac{0.58}{0.58} : \frac{1.167}{0.58}$$

$$1 : 2$$

$$x = 2$$

(ii) Describe a test for calcium ions in the sample of gypsum.

~~DO~~ Flame test orange flame and
~~add aqueous sodium hydroxide gives~~
~~white precipitate~~

(Total for Question 6 = 15 marks)

TOTAL FOR PAPER = MARKS

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